Daun Bekor- As Possible Drag Reducing Agent (DRA) in Pipeline

by

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Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Petroleum Engineering)

SEPTEMBER 2011

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the

Geoscience and Petroleum Engineering Programme

Universiti Teknologi PETRONAS

in partial fulfilment of the requirement for the

BACHELOR OF ENGINEERING (Hons)

(PETROLEUM ENGINEERING)

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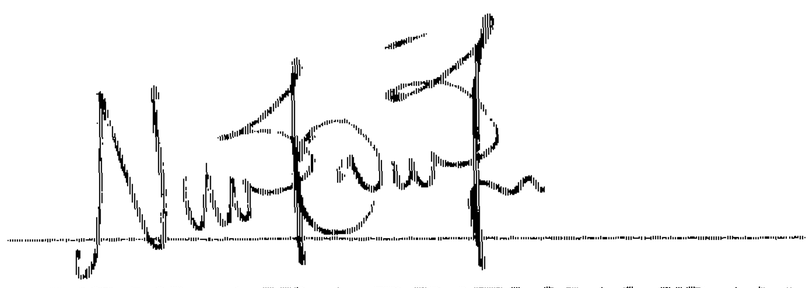
September 2011

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is myown except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



NURUL AIDA BINTI HAMDAN

ABSTRACT

Most offshore oil and gas production is transported by pipelines to onshore facilities. During the past few decades, power saving and reduce of power consumption in the pipeline systems are one of the major issues. In this study the effect of the presence of a drag reducing agents (DRAs) on the pressure drop pipelines are investigated. Surfactants and polymers are commonly used as DRAs in pipeline transportation system.In this present experiment; the objective is to investigate the effectiveness of new formulated natural polymer, *'Daun Bekor'* as drag reducing agent (DRA). Additives concentrations at 100ppm, 300ppm, 500ppm, 700ppm, 1000ppm, 3000ppm, 5000ppm and 8000ppm will be tested in a flow test experiment with pipe diameter is 0.0254 meter ID and testing section length of 4 meter. The results of this experiment will be discussed based on the identified parameters.

ACKNOWLEDGEMENT

Alhamdulillah. Thanks to Allah SWT, who with His willing to give me the opportunity to complete this Final Year Project which entitled Daun Bekor- As Possible Drag Reducing Agent (DRA) in Pipeline. This final year project report was prepared for Geoscience and Petroleum Engineering Department of Universiti Teknologi PETRONAS, basically for student in final year to complete the undergraduate program.

First and foremost, I would like to express my deepest thanks to my supervisor, Puan Mazlin Idress, for providing me the opportunity to work under his supervision. She provided all the required resources, support and guidance at every step to complete this project. She could always find time for discussions and overview my work. Moreover, she enormously helped me in progressing in my work and helped me to complete my FYP 1 during semester January 2011. This project would not have been possible without her cooperation and assistance.

Secondly, I would like to extend my appreciation and gratitude to my colleagues who gave me a lot of valuable information, suggestions and guidance through the completion of this final year project. To Fadhilah, Awang and Hafizi, your cooperation, time and encouragement given to see this project successful are very appreciable. To Syima, thanks for reducing some of the pressure when things were stressful.

Last but not least, I would like to thank my family for the support and encouragement I received while doing my project. I would like to thank my parents for the constant support, especially during the past few months. To Angah, thanks for your financial support in the fabrication part of this final year project. And most importantly, I would like to thank Syafiq for being there for me and making me laugh even when times were hard for you. Thanks for pushing me to be the best, and giving me a shoulder to lean on when times were hard.

1. INTRODUCTION

1.1 Background of Study

Drag by definition means 'a heavy, pulling action'. Drag also identifiable as the mechanical force that exists in the pipeline that more suitable to be define as friction exists at the near wall region that decreases velocity. In the other hand, in fluid flow, drag reduction means lessen the effects of friction of turbulent flows that occur in pipeline.

In a hydrocarbon stream, turbulent flow regimes could cause a frictional pressure drop in a fluid flow. The pressure loss will decrease the flow rate in the pipeline leading to an increase in the pumping requirements of such systems. Drag reduction is one of the alternatives that were identified which can be applied in a short time and does not require a high initial investment compared to developing other pipelines. This option can help to boost the economic benefits of oil pipeline transportation systems. The term drag reduction, as recognised in the art, is the increase in the volumetric flow rate of fluid at a constant pressure drop due to the addition of a material known as drag reducer or DRA to the flowing fluids.

1.2 Problem Statement

The flow of multiphase, oil/water/gas mixture in the pipeline is encounted frequently in the petroleum industry. Initially, most oil wells consist of mainly oil and gas. But the content of water can increase up to 90% during the life of the well. The long distances involved in fluid transportation can be a significant problem for pressure drop, and for corrosion and its inhibition since many oil wells are located in remoted sites.The installation of pumping stations may be required due to the pressure drop in the pipeline, which leads to an increase of additional capital and operating costs. This phenomena lead to the growth of researches in order to minimize the power supply in pipeline systems. Currently, Drag Reducing

Agent (DRA) have marked as an economic and environmental friendly alternatives to reduce power losses in pipeline, thus increased the flow capacity without adding any installment or extra energy. However, there is mechanical and chemical restriction in using polymeric DRA. These restrictions due to the structures of polymer that easily degraded due to shear forces and free radicals that reduce the effectiveness of polymeric DRA.

1.3 Objective

The objectives in this research are to:

- Determine the properties of DRA in terms of its rheological, thermal, chemical or physical properties.
- Identify the most suitable procedures in extracting natural polymer by using *daun bekor* mucilage as raw material.
- Investigate the drag reduction ability of new formulated natural DRA which is *daun bekor* mucilage.
- Investigate the most suitable flow rate, pipe diameter and concentration in reducing pressure drop.

1.4 Scope of Study

In reducing pressure drop in pipeline by using natural polymers as DRA, there are manipulated variables and constant variables to be set up. By manipulating variables, pressure drop can be determined by manometer. There also some limitations that the author suggested of these studies to ensure all results are base on parameters. The suggested limitations are:

- Using one length of galvanized iron pipeline which is 4 metres.
- Using water as the solvent.
- Using 8 different concentrations of DRA

- Using pipe with internal diameters 0.0254 m
- Using different flow rate that related to all parameter and dependable on pipe diameter and pressure drop.

1.5 The Relevancy of the Project

This research is to study the effect of *daun bekor* as DRA to reduce the turbulent friction factor of the fluid in pipeline. If this research is successful, it will give great impact to the industrial application especially in pipeline systems. Rationally, this research can help to develop another environmental friendly alternative to overcome losing energy in transporting liquid using pipelines especially in long distance transportation such as in Trans Alaskan Pipelines (TAPS), Turkey-Iraq Pipeline, Bas Strait (Australia) Pipeine, Bombay Off Shore (India). This is because, by studying the effects of drag reduction, its can help to reduce energy supply in transporting the liquids from one distance to another. Therefore, cost can be saving by adapting Drag Reducing technology in pipeline system.

This research also can determine the most suitable natural polymeric Drag Reducing Agent by identify the most suitable treatment in extracting natural polymer which is *daun bekor* mucilage as raw material. As a result, environment can be safe because this natural polymer is an environmental friendly (biodegradable) DRA.

2. LITERATURE REVIEW

Drag Reducing Agents (DRAs) are any material used to reduce or minimize the frictional pressure loss caused by turbulence in the pipeline. However, there are major problems in using polymeric DRA which is polymer is easily degraded due to mechanical force and chemical degradation. Drag reducing agent (DRA) is an additive that highly viscous disperse in pipeline to help reducing friction pressure losses. In economic view, by adding DRA, pressure losses can reduce. So, cost of production can minimize by reducing energy consumption in pumping system and installments of pipelines and delayed pump station. In this chapter discussed the literature review on turbulent flow, drag reduction, DRA and drag mechanism.

2.1 Drag Reduction

Drag reduction can be defined as a flow phenomenon by which the friction of a liquid flowing in a duct in turbulent flow is decreased by using a small amount of an additive. Aim of the drag reduction is to develop the fluid mechanical efficiency using active agents that known as DRAs. DRAs are effective because they reduce the turbulent friction of a solution. These results in a decrease in the pressure drop across a length of a conduit and likewise reduce the energy required to transport the liquid.

2.2 Drag Reduction Mechanism

In the fluid dynamic concept, there will are main different characteristic of flows which are laminar flow and turbulent flows. For laminar flows as in Figure 1, there will be no major problems because at laminar flow of liquids can be assume as steady state. Laminar flows have uniform velocity that is $\partial V / \partial t \equiv 0$. Laminar is a stable, smooth parallel flows which do not encounter disruption

between flow layer because of high momentum diffusion and low momentum convection. The Reynolds Number of laminar flow is below than 2100.

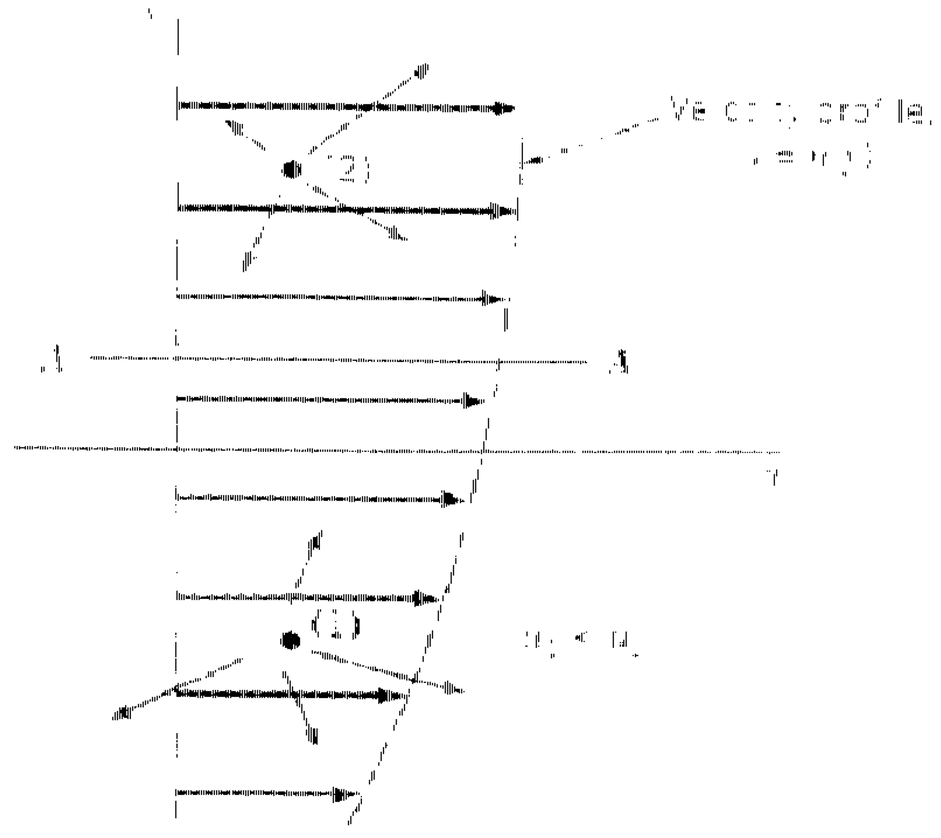


Figure 1: Laminar Flows Mechanism

The problems start to occur when flows momentum convert their energy in time of period from high momentum diffusion and low momentum convection to low momentum diffusion and high momentum convection. This phenomenon called turbulent.

Turbulent is an unstable, chaotic flow denominated by recirculation (fluid molecules rotation), eddies and apparently randomness of the flow alignment. Turbulent is cause by increasing of velocity in fluid motion denoted by $\partial V / \partial t \neq 0$. Turbulent furthermore can cause fluctuation of parameters such as velocity, pressure and temperature. The Reynolds Number of turbulent flow is greater than 4000.These fluctuations lead to high momentum convection and the production of unsteady vortices or eddies which lead to an increase in skin friction.

When fluids motion increase due to momentum convection, which transporting energy and molecules trough pipes and so increase various velocity of fluid motion. There also molecules tend to be stagnant at their origin place which

influence by inertia. Inertia is the resistance of molecules has to a change in its state of motion. Therefore, the static molecules will forms boundary layers between pipe wall and the molecules of solvents.

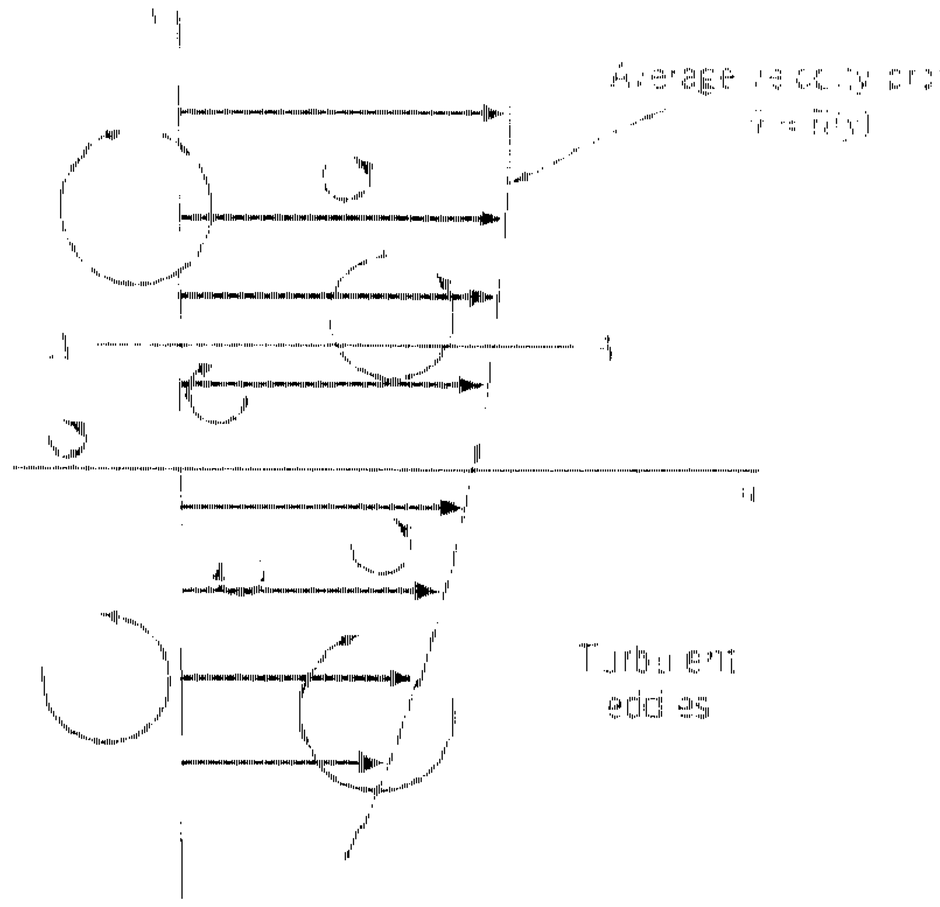


Figure 2: Turbulent Flows Mechanism

As illustrated in Figure 2, flux momentum across from point A to point B in x direction. The acceleration is equal for all solvents molecules. Because of inertia existed at pipeline wall, so the flux momentum in some how will be in opposite direction. This called drag. Energetic molecules at the center of pipeline will be slow down by solvent molecules at the outer of pipelines. The rate of change in momentum is known as shear force. In addition, there are attractive forces between solvents molecules. This phenomenon happen base on the law of momentum convection which state, "Total momentum of any group of objects remains the same unless outside forces act on the objects". Because of random motion of the flows, eddies will formed.

In turbulent flows, the friction at the wall of the pipes will lead to the further decrease of flows and tendency to form vortices is high because the friction will 'hold' liquid molecules at the buffer region. Therefore, friction in boundary will increase drag. Thus, energy will be loss due to formation of vortices and eddies. Buffer region is a part in the pipeline which the molecules of water has

losses their energy and the alignment of flows and will be 'stuck' at the pipeline wall because molecules of liquid do not have enough energy to against wall friction.

DRAs interfere with the bursting process or inhibit the formation of the turbulent burst and prevent the turbulence from being formed, or at least reduce the degree of turbulence, and in turn reduce the drag or pressure loss. The DRAs somehow stretch in the flow, absorb the energy in the laminar sub layer called "streak" and thereby prevent the turbulent burst. As such, DRAs are most effective in the buffer zone. The mechanism is showed in Figure 3.

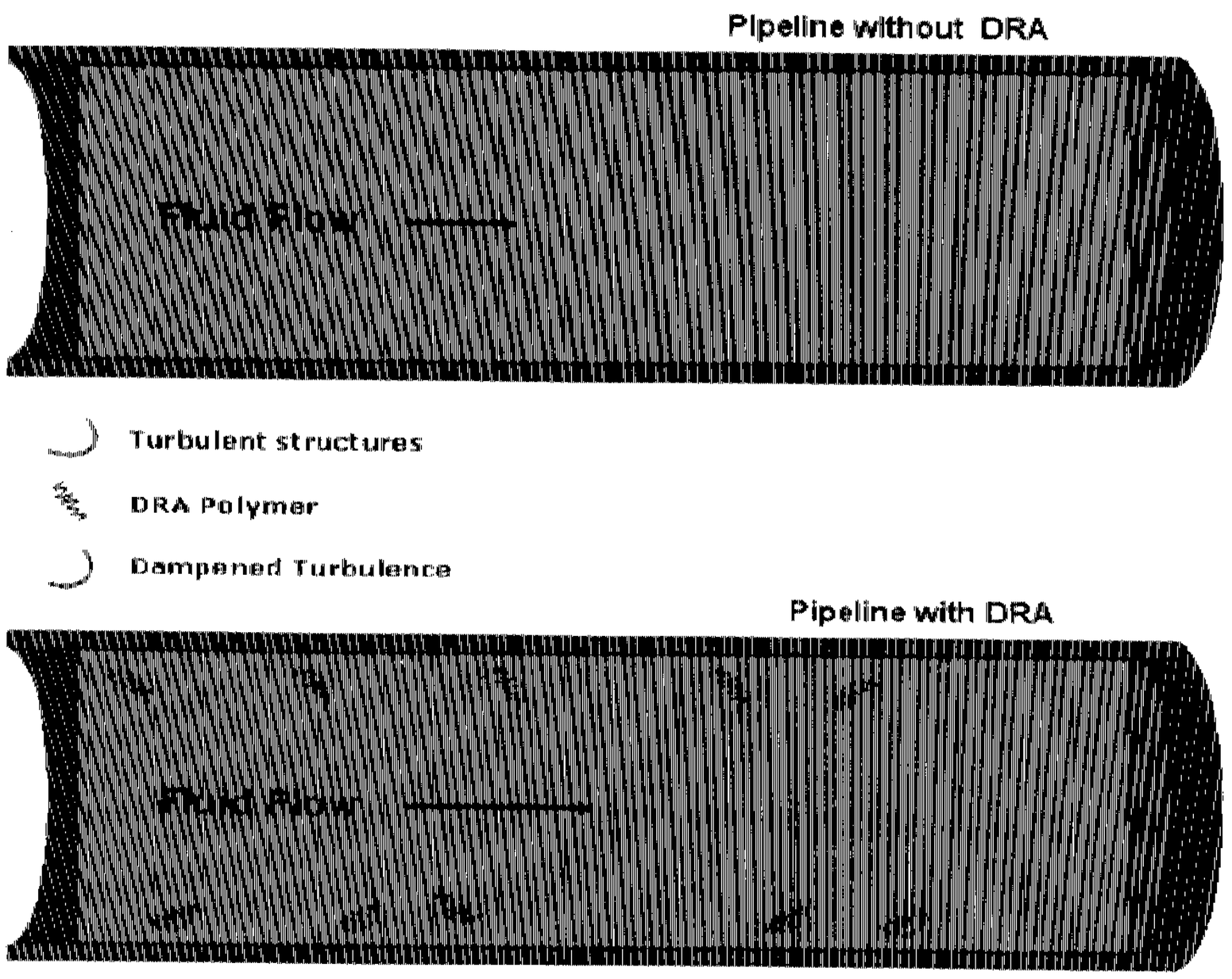


Figure 3: Drag Reduction Mechanism

2.3 Drag Reducing Agent

DRA is one of the innovations in enhancing the flow in pipeline. To ensure the pipeline is in place and to avoid harmful damage or corrosion before its time, many companies will increase their flowrate. This will lead to various motions

called turbulent flows. As known, turbulent flows will increase vorticityforce and decrease velocity. So, DRA usually will be injected at the centered pipeline during peak time which means the pump down in the flow line condition. DRA can bursts the buffer zone, increase streaks in pipeline, decrease vorticity force and increased velocity of flow without supplying extra energy.

Drag reducing agent are any material that reduces frictional pressure during fluid flow in a conduit or pipeline. Using DRA allows increased flow using the same amount of energy or decreased pressure drop for the same flow rate of fluid in pipelines. Drag reducing agent are the additives of polymer, surfactants or suspended solid that act as the helper to prevent eddies in turbulent flows. These additive are helping to save the energy by reducing the recirculation effects (prevent liquids molecules to rotate) that existed in turbulent flow. (Lumley, 1969) definition of drag reduction is "Drag reduction is the reduction of skin friction in turbulent flow below that of the solvent". DRA can affect the solvent by changing viscosity of the solvents. Fluid elasticity in DRA also hinders the oscillation-induced streaming suggested by (Vlassopoulos and Schowalter, 1994).

2.3.1 Polymeric DRA

DRA can be classified into three major categories; polymers, surfactants and fibres. In general, polymers are most effective from the industrial point of view and the most usable in the industries applications. It is known that, polymers are divided into two types: synthetic polymers and natural polymers. Synthetic polymers are derived from petroleum oil, while natural polymers are extracted from resource in nature.

To date, polymer solutions are the most widely studied and most often employed of the drag reducing systems. Several typical polymer drag reducing solutions available in the market are shown in Table 1.

Table 1: Drag reducing polymer solutions

Water-soluble polymers	Solvent-soluble polymers
Poly(ethylene oxide)	Polyisobutylene
Polyacrylamide	Polystyrene
Guar gum	Poly(methyl methacrylate)
Xanthan gum	Polydimethylsiloxane
Carboxymethyl cellulose	Poly(*cis*-isoprene)
Hydroxyethyl cellulose	

Although synthetic polymers posseses good mechanical properties and thermal stability when used as flow improvers in pipelines, these materials biodegrade very slowly, which is an environmental concern. On the other hand, natural polymers are biodegradable and can be easily obtained. Indeed, these materials are produced in the form of polysaccharides by microorganisms and plants. Daun bekor in this research is an example of plant that be assumed contains a high amount of natural polymers.

2.3.2 Surfactants DRA

The term surfactant came from the contraction of "surface active agent". Surfactants are proven to be drag reducer in turbulent flow in pipes because of their drag reduction ability at concentrations as low as part per million was carried by the micelles present in the solution. Surfactants are molecules which contain a hydrophobic tail and a hydrophilic head group. Surfactants can be further classified by their hydrophilic group. The different types of surfactants are anionic, nonionic, zwitterionic, and cationic.

Surfactants behave in a characteristic manner in aqueous solution. In these solutions the hydrophobic groups avoid contact with water by forming micelles. In micelles the hydrophilic parts, which are polar,

contacts the water allowing the non-polar, hydrophobic, parts to concentrate in the center of the micelle. The micelles form different structures in aqueous solutions including spherical, rod-like, lamellar, and vesicles. The types of surfactant as well as the structure of the micelle both contribute to the drag reducing properties of the molecule.

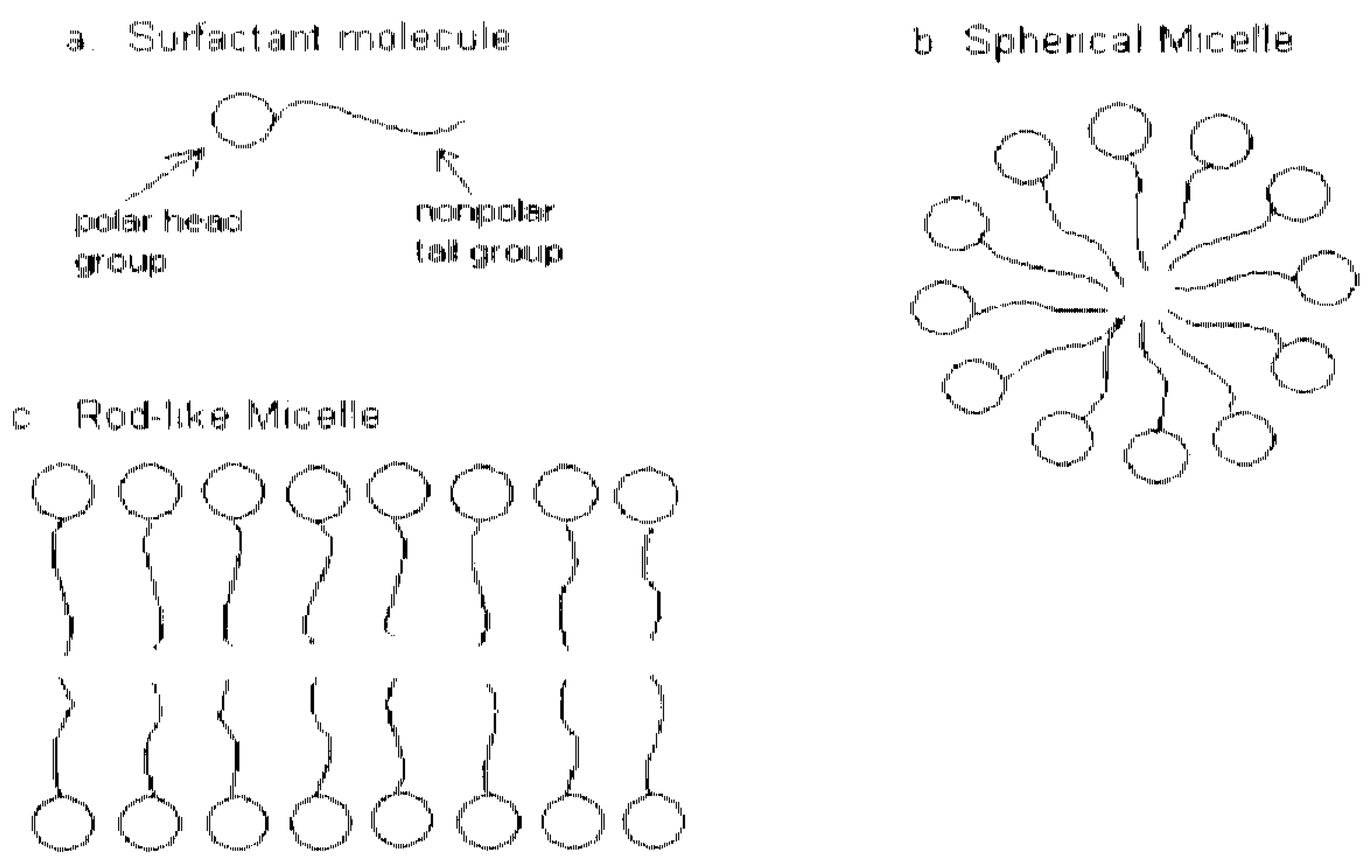


Figure 4: Micelle Structures

2.3.3 Fibres DRA

On the other hand, the use of fibre additives as drag reducer in pipelines remains limited. There are however, few experimental studies had shown that the drag reduction effects for these additives up to 60% in pipe flows. Depennding on the flow geometry, the particle size and the importance of viscous effects versus inertial effects, the addition of fibres to a flow can have either a stabilizing or a destabilizing effect. There are much less studies devoted to the effects of fibre additives on the mechhanism of instability and transition to turbulence in flow since there are not as effective as polymeric and surfactant DRA.

2.4 Comparison between Polymer and Surfactant DRA

Formation of micelles and their shapes are main factors influencing the drag reduction ability of the surfactant solutions. The main characteristics feature of the friction behaviour of surfactant solutions is the disappearance of drag reduction when a critical wall stress is reached. The spherical micelle is generally conceived as a small ball-like particle of colloidal dimensions and fairly constant in size for a given surfactant. These spherical micelles exist only in relative dilute solutions. In concentrated solutions, however, the lamellar micelle is favoured. When one compares the data for surfactant solutions with that for polymer solutions, it becomes obvious that the drag reduction behaviours in these two cases are different.

While the soap solution exhibits drag reduction low wall shear stress values, the polymer solutions show relatively small drag reduction at low Reynolds numbers and increasingly large reduction at high Reynolds numbers. These two types of behaviour are obviously a consequence of the difference between micellar and polymeric structures. It can be assumed that;

(a) the flexible polymer molecule needs to be elongated by a large velocity gradient before its full drag reducing ability is developed, and

(b) the surfactant particles are oriented much more easily at lower velocity gradients, but the micelles collapse at high shear stresses associated with large velocity gradients.

In terms of equivalent molecular weight, micelles are known to have larger values than polymers and therefore they would shift the onset of drag reduction to a lower shear stress value.

2.5 Theory

Since the discovery of the drag reduction effect, several theories for the phenomenon have been proposed. All of these are semi-empirical or highly speculative, and all have been subjected to criticism.

The first explanation of polymeric drag reduction was given by Oldroyd (1949), who proposed the persistence of anomalous behaviour in a thin laminar layer at the pipe wall when the main stream has become turbulent. The principle is that an external constraint is imposed by the wall on the ways in which long-chain molecules can rotate near the wall; therefore an abnormally mobile laminar sublayer, of a thickness comparable with molecular dimensions can exist at the wall, which causes an "effective slip".

Another kind of wall effect was proposed by Elperin et al. (1967). They suggested that an adsorbed layer of polymer molecules could exist at the pipe wall during flow and this could lower the viscosity, create a slip, damp turbulence and prevent any initiation of vortices at the wall.

Later studies have put more emphasis on the interaction which takes place between the polymer and the turbulence. For instance, the existence of a drag reduction onset Reynolds number *NRe* is a reection of this interaction. Virk et al. (1967) stated that onset occurs if the ratio between the turbulence and the polymer length scales reaches a critical value. Lumley (1973) found this mechanism unlikely, since the smallest turbulence length scale is several orders of magnitude larger than the size of the polymer molecules, so that this parameter must be dynamically immaterial to the flow. As an alternative, he proposed that onset occurs when the ratio of turbulence and polymer time scales is of order one.

After onset, some interaction between the polymer molecules and the turbulent flow results to give drag reduction. Lumley (1973) proposed that the

increase of effective viscosity in regions with strong deformations (in which the polymers expand), may be the key to drag reduction. These regions would primarily exist in the buffer layer, where the strongest turbulence activity is present. By applying a rather crude scaling analysis, Lumley (1973) indeed obtained a reduction in drag by increasing the effective viscosity outside the viscous sublayer.

Based on the brief review, we conclude that the explaining theories for drag reduction may be divided into two major categories. In the first place, there is an explanation in which drag reduction occurred only in turbulence flow. Second, a theory that stresses the increase in extensional viscosity for the polymer solution is the main ingredient.

3. METHODOLOGY

3.1 Experimental Details

A series of laboratory tests had been conducted during this project. Results of the tests were analyzed whether the liquid extracted from 'Daun Bekor' could be a good DRA in pipeline. The experimental work is divided into 2 sections:

3.1.1 Preparation of *daun bekor* mucilage

1. The immature leaves *(daun bekor)* were chopped into small pieces.

2. 1000ml of distilled water is poured in a beaker to prepare 100ppm DRA solution

3. Then, 0.1g of leaves are soaked in the beaker filled with 1000ml of distilled water for 30 minutes.

4. The mixture is stirred slowly and gradually being heated up for another 30 minutes to motivate and speed up the extraction operation. The temperature should not exceed or reach boiling temperature to avoid evaporation.

5. After the soaked leaves produce mucilage that change clear water into very thick viscous green in color, allow the solution to cool down.

6. Then leaves mucilage will be filtrated by muslin cloth to prevent any big colloidal and suspended solid to get through.

7. Steps 2-6 is repeated by changing the mass of leaves to 0.3, 0.5, 0.7, 1.0, 3.0, 5.0, and 8.0 grams to create series of DRA solution with concentration of 300, 500, 700, 1000, 3000, 5000 and 8000ppm.

In conducting the experiment, the author had prepared the DRA solution with various concentrations as shown in the table below:

Table 2: DRA Solutions

Mass (g)	0.1	0.3	0.5	0.7	1.0	1.5	2.0	2.5
Concentration (ppm)	100	300	500	700	1000	1500	2000	2500

3.1.2 Flow test experiment

The laboratory experiment was performed in the straight pipe flow facility system which fabricated by the author herself to fulfil the investigation requirements. The main part of the system consists of a cylindrical galvanized iron pipe with a length of 4 m and an inner diameter of 0.0254 m (ID). An injection entry point of DRA is located in the middle of the pipe right after the pump section. A pressure gauge testing section is to be found at the end of the pipe flow system. This test is about to ensure that the turbulent flows were fully developed before the testing point.The experimental flow diagram is showed as in Figure 5.

The transported liquid for this experiment is water. The physical properties of water are shown in Table 1.

Table 2: Physical properties of water

Water properties @ 25°C	Values
Viscosity ($\mu_{water25°C}$)	0.8973×10^{-3} Pa.s
Density ($\rho_{water25°C}$)	997.08 kgm^{-3}

The operation will begin when the pump starts delivering the solution through the testing section. Before the addition of polymers in the tank, pressure drop will be measured as a function of water flowrate.

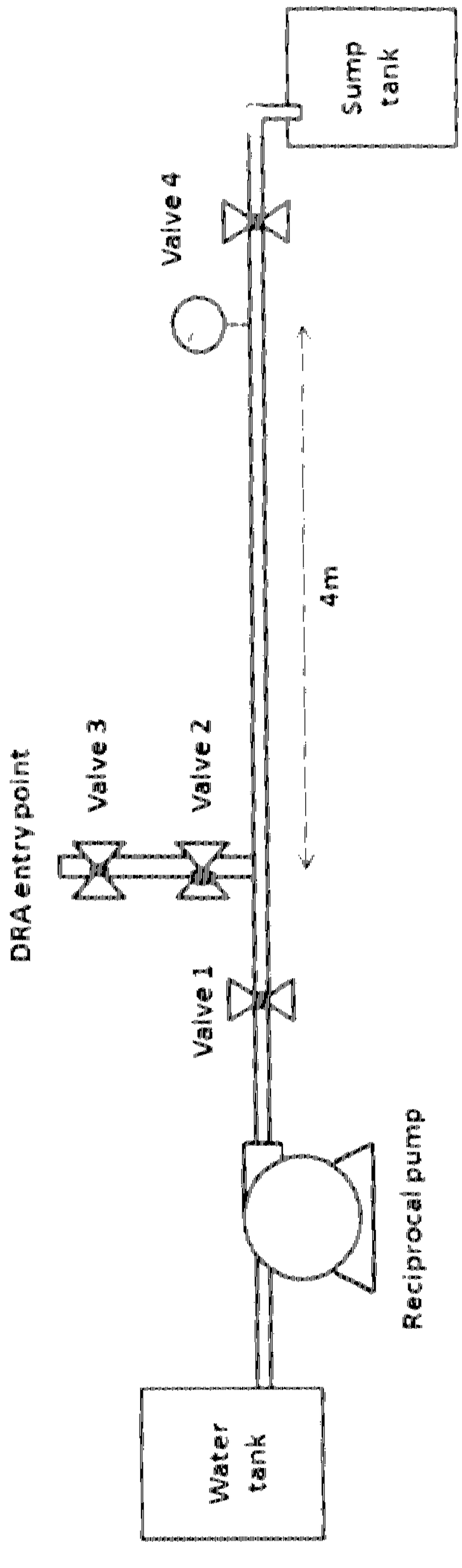


Figure 5: Schematic Diagram

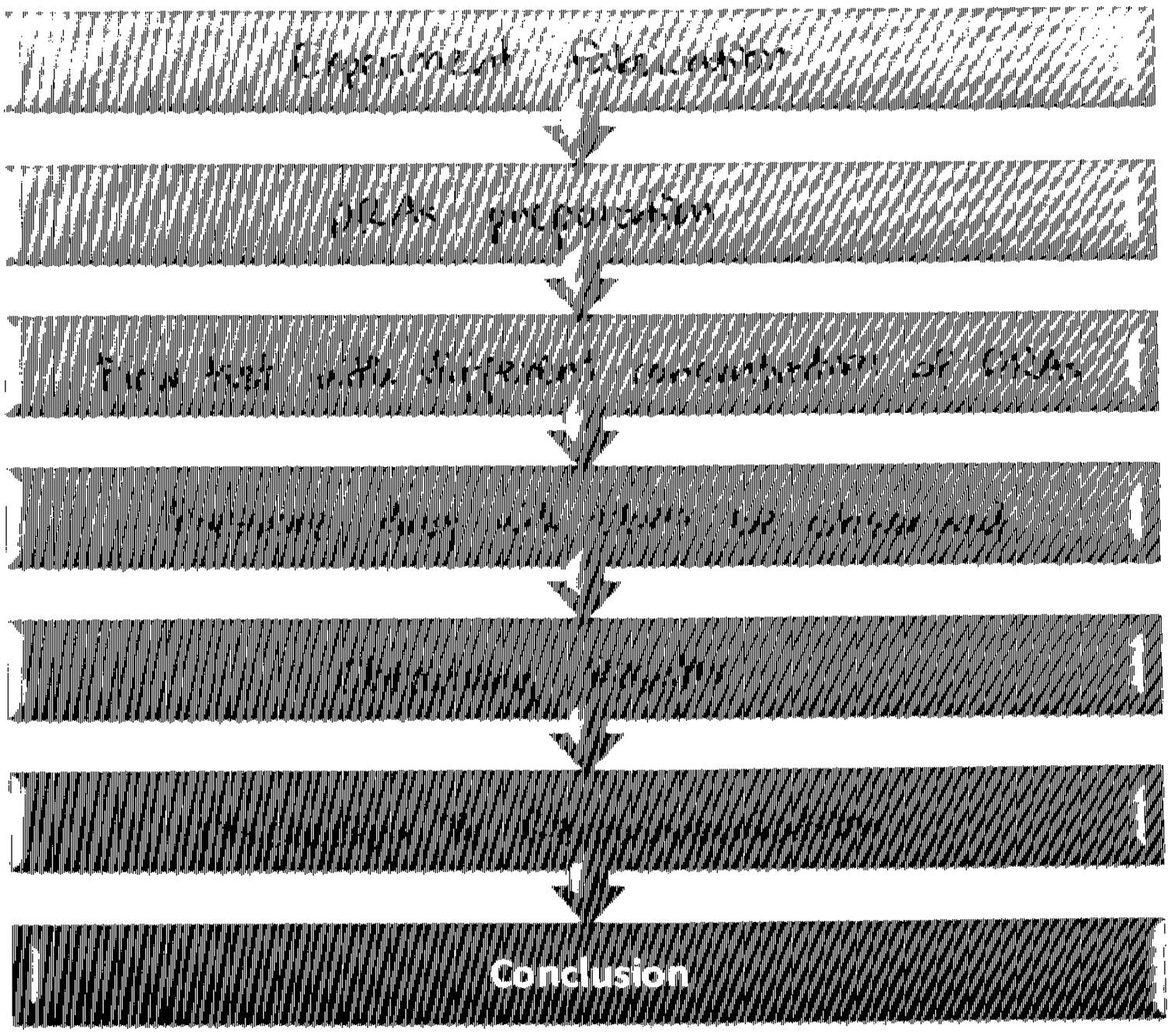
Before the addition of DRA in flow test system, pressure drop was measured as a function of water flowrate. DRA was tested at different concentration and the pressure drop readings were taken and compared with the readings for pure water (no addition of DRA).

Experimental procedures are as below:

1. Before the pump starts, valve 1 and valve 4 are need to be opened while valve 2 and valve 3 are closed.
2. The operation begins when the pump is started. The solution will be delivered through the testing section. Pressure reading is taken to this flow rate.
3. Then, valve 1 and valve 4 are closed. The pump will be turned off.
4. Valve 3 is opened to add the DRAs solution into the flowing fluid inside the pipe.
5. Then, valve 2 will be opened while valve 3 is closed to let the DRAs solution mix with the flowing fluid.
6. The pump is started again.
7. Valve 1 and valve 4 will be opened slowly to flow the fluid mixed with the DRAs solution.
8. Pressure drop readings are taken and compared with the readings for pure water without DRAs.
9. This procedure is repeated for each DRAs concentration to test its effect on the drag reduction operation.
10. The pump is turned off after getting the pressure drop readings. All datas are tabulated and plotted on the graph.

The experiment and work procedure for this test is represented by the chart below:

Chart 1: Workflow



3.2 Materials, Equipment and Tools

Materials used for this experiment were as follows:

- Daun bekor mucilage as DRA
- Distilled water
- Water

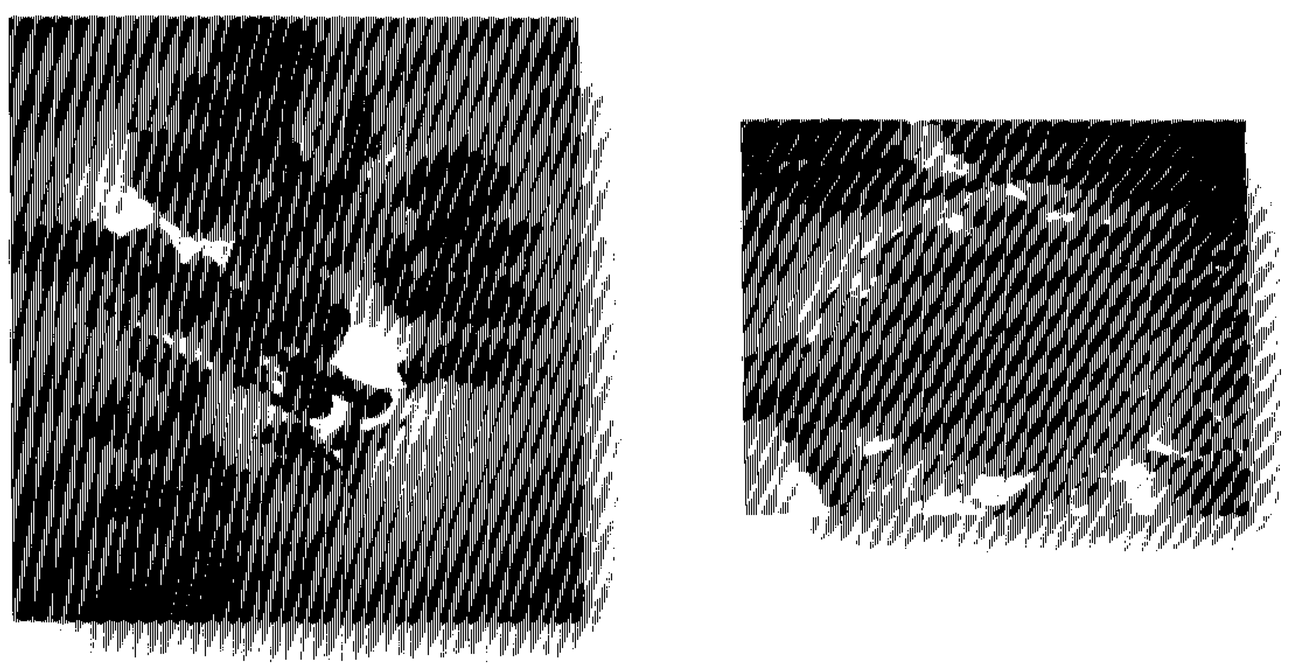


Figure 6: Daun Bekor

Equipment and tools used in this experiment:

- 7 m of galvanized iron pipe
- Reciprocal pump
- Valves
- Pressure gauge
- Drainage tank
- Water tank
- Magnetic Stirrer
- Viscometer
- Density meter

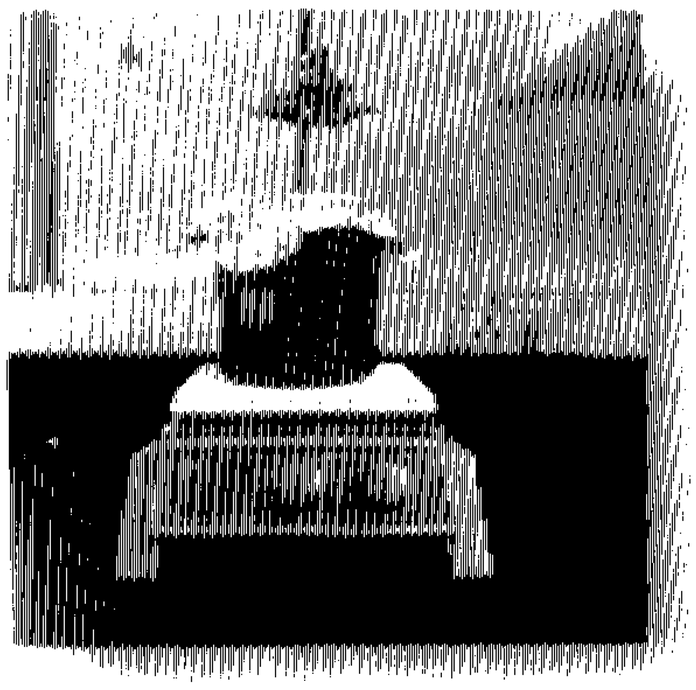


Figure 7: Magnetic Stirrer

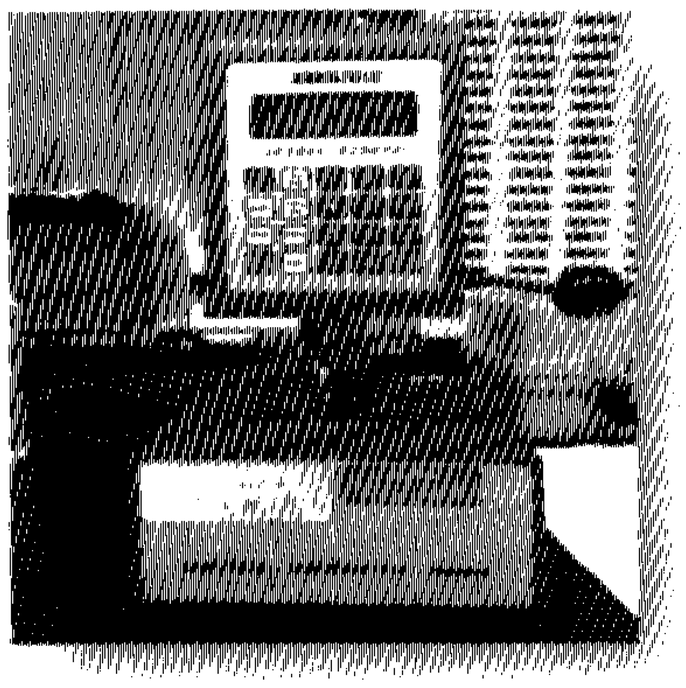


Figure 8: Viscometer

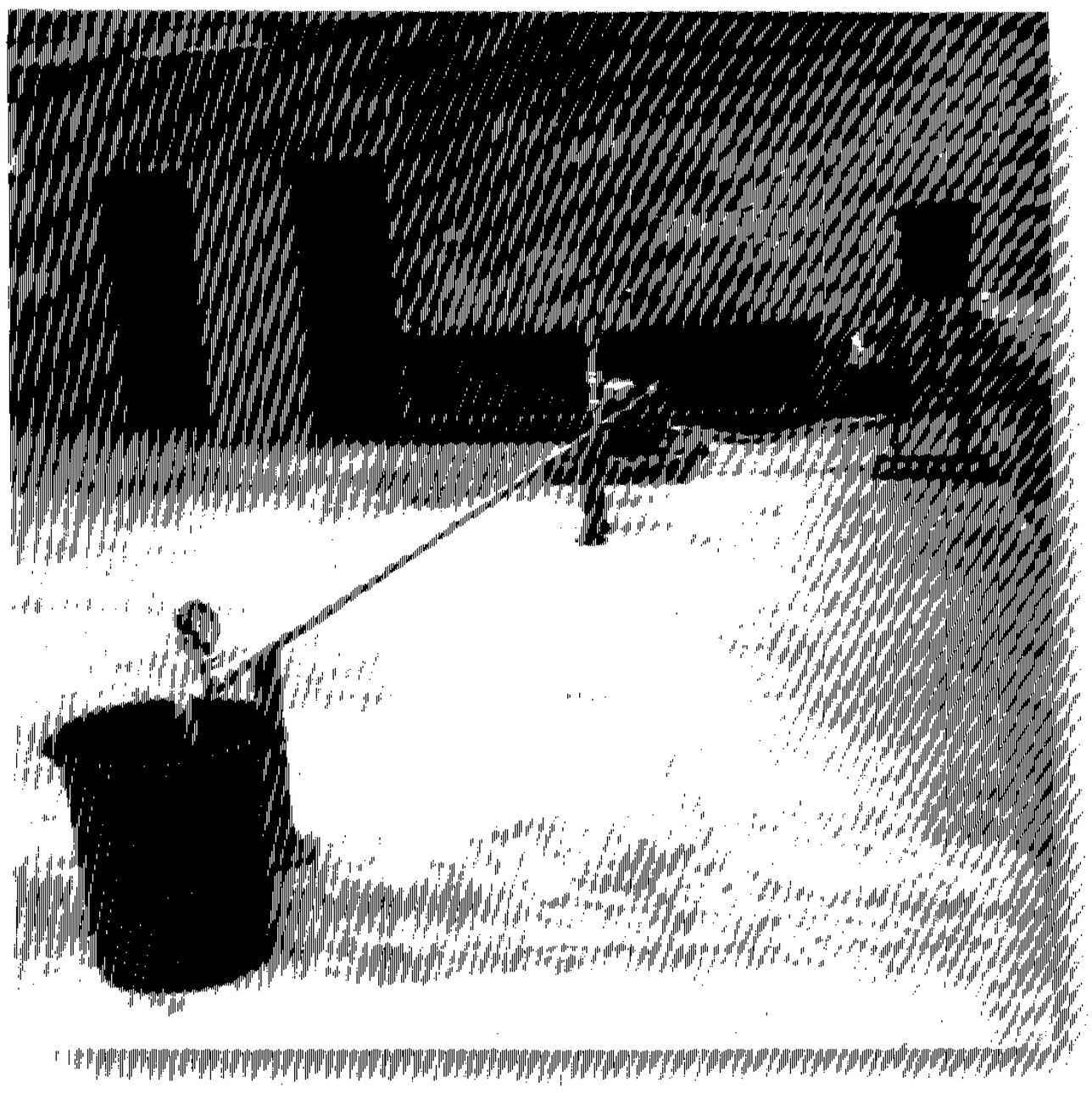
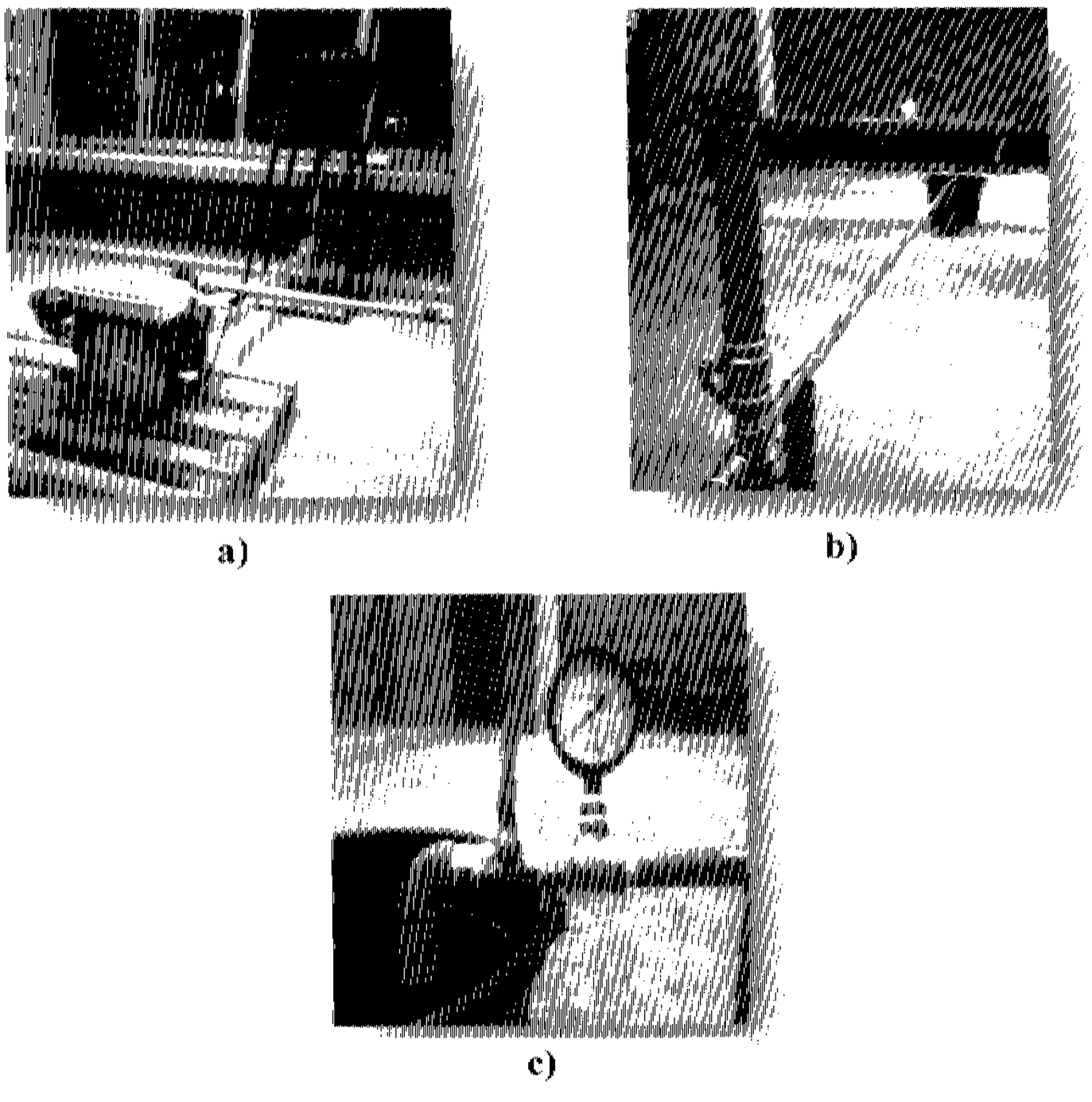


Figure 9: Flow test equipment



a) **b)**

c)

Figure 10: a) Reciprocal pump b) DRA enter inlet c) Pressure gauge

3.3 Key Mile Stone and Gantt chart

Table 3: Key Mile Stone

No.	Activities	Date/Week
1.	Briefing and update on students progress	W4
2.	Project work commences	W1-W8
3.	Submission of progress report	W8
4.	PRE-EDX	W11
5.	EDX	W12
6.	Delivery of Final Report	W12
7.	Final Oral Presentation	W14
8.	Submission of hardbound copies	W16

Table 4: Gantt chart for 2nd Semester Project Implementation

No.	Detail/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Attain required materials and equipment														
2.	Fabricate the experiment														
3.	Preparing the DRA solution														
4.	Testing the equipment set up for any improvement														
5.	Conduct flow test experiment														
6.	Preparation of progress report														

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
7.	Submission of progress report														
8.	Continue experimental work														
9.	Interpret predicated parameters and results														
10.	EDX														
11	Submission of Draft Report														
12.	Submission of Dissertation (Soft Bound)														
13.	Submission of Technical Paper														
14.	Oral Presentation														
15.	Submission of Project Dissertation (Hard Bound)														

4. RESULTS & DISCUSSION

4.1 Experimental Calculation

Velocity and Reynolds Number calculations:

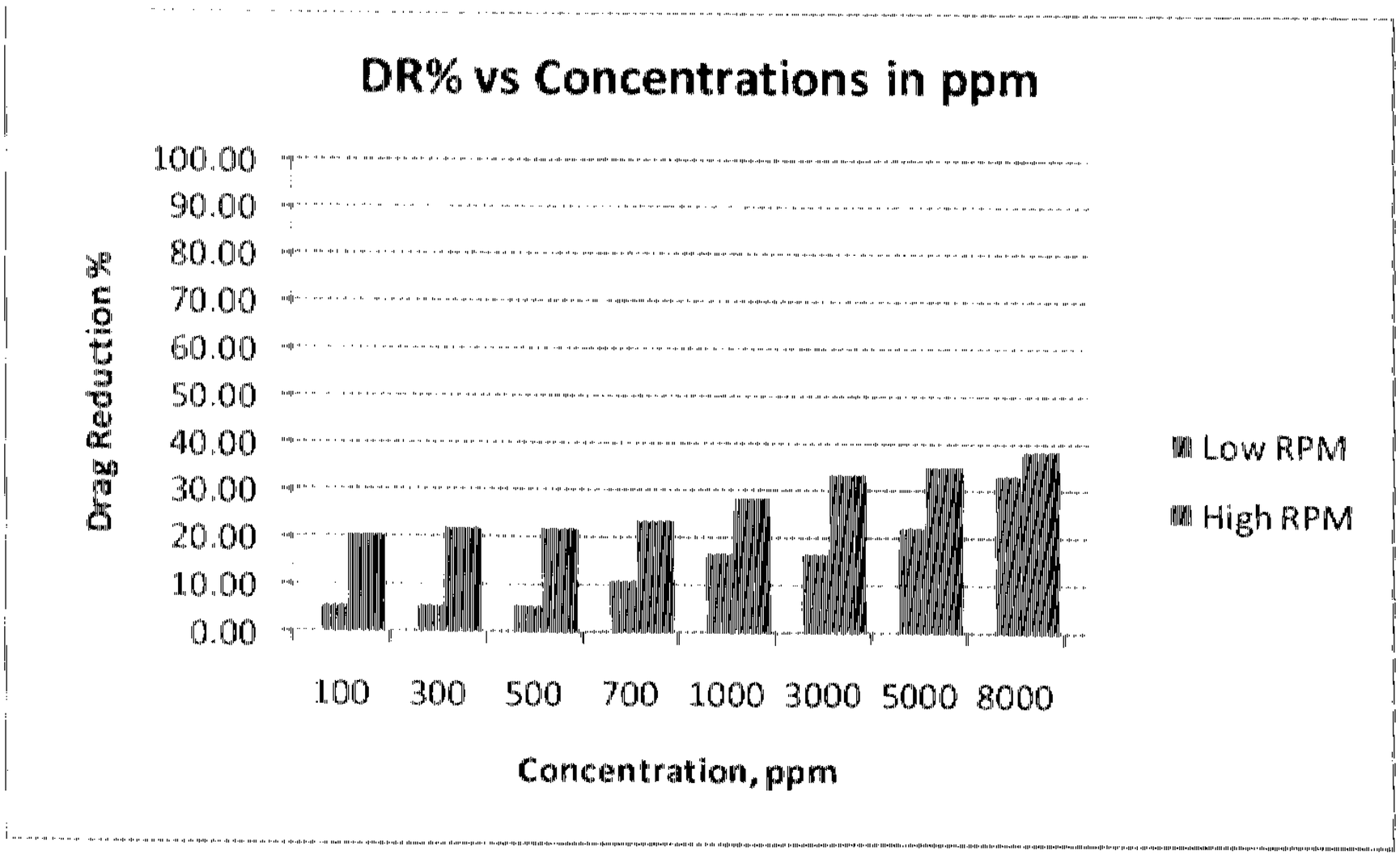
The average velocity (V) and NRe were calculated using the solution volumetric flow rate readings (Q), density (ρ), viscosity (μ) and pipe diameter (D, for each run as follows:

$$NRe = \frac{\rho VD}{\mu}$$

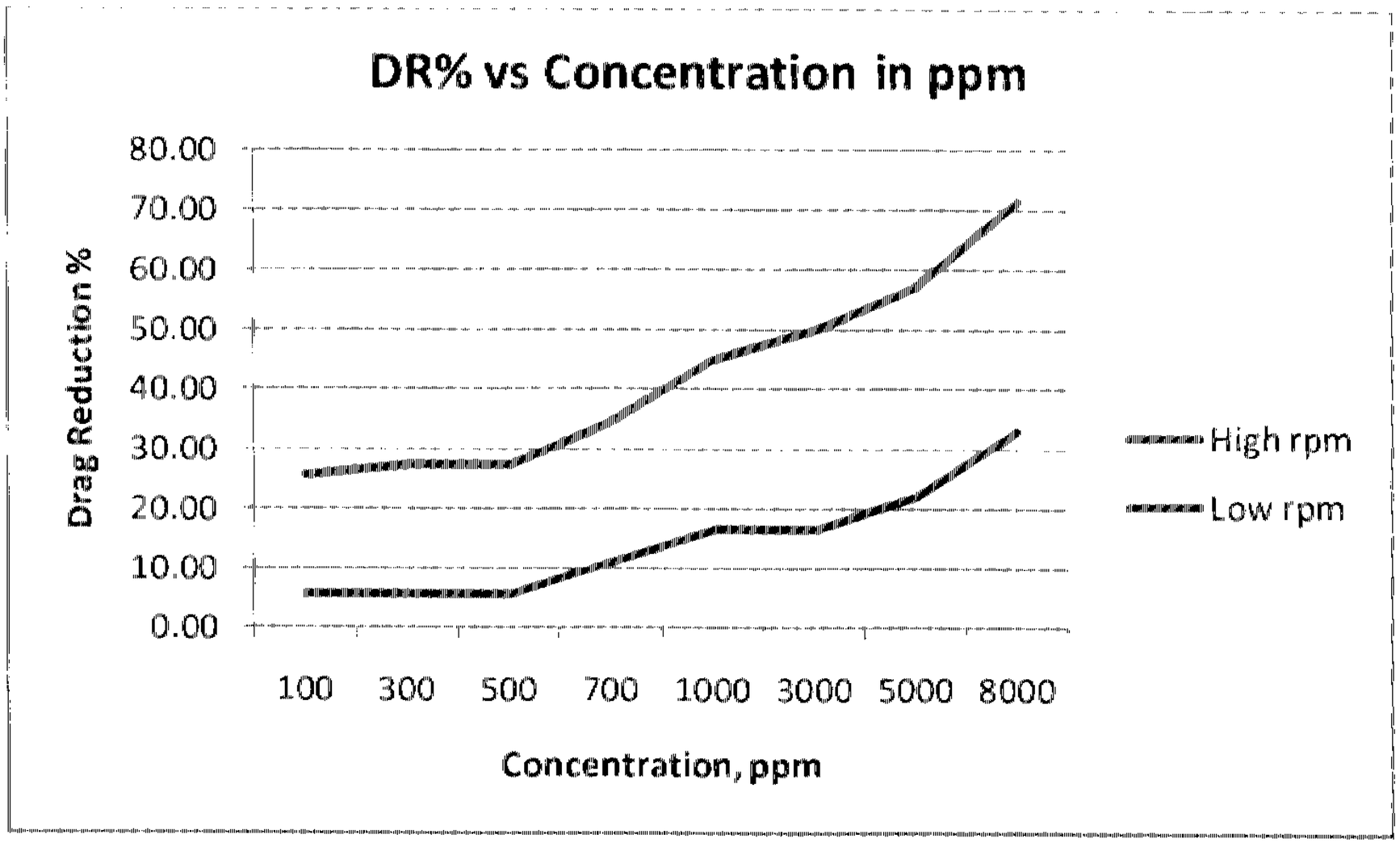
Percentage of drag reduction calculation:

Pressure drop reaings through testing sections before and after drag reducer addition, were needed to calculate the percentage drag reduction %DR as follows:

$$\%DR = \frac{\Delta P1 - \Delta P2}{\Delta P1}$$



i.



ii.

Figure 11: i and ii Drag Reduction % vs concentration of DRA in ppm

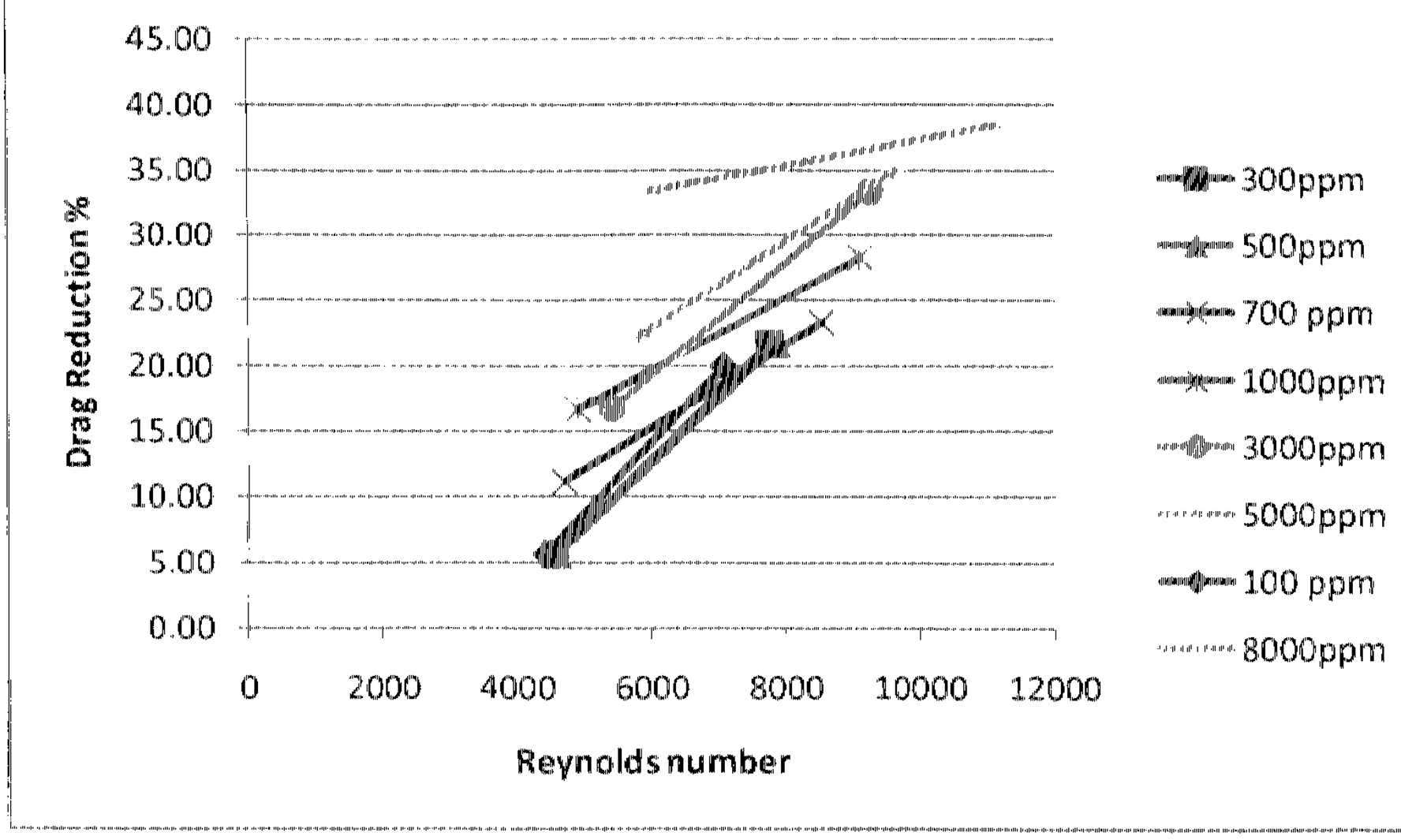


Figure 12: Drag reduction % vs Reynold Number at low and high rpm

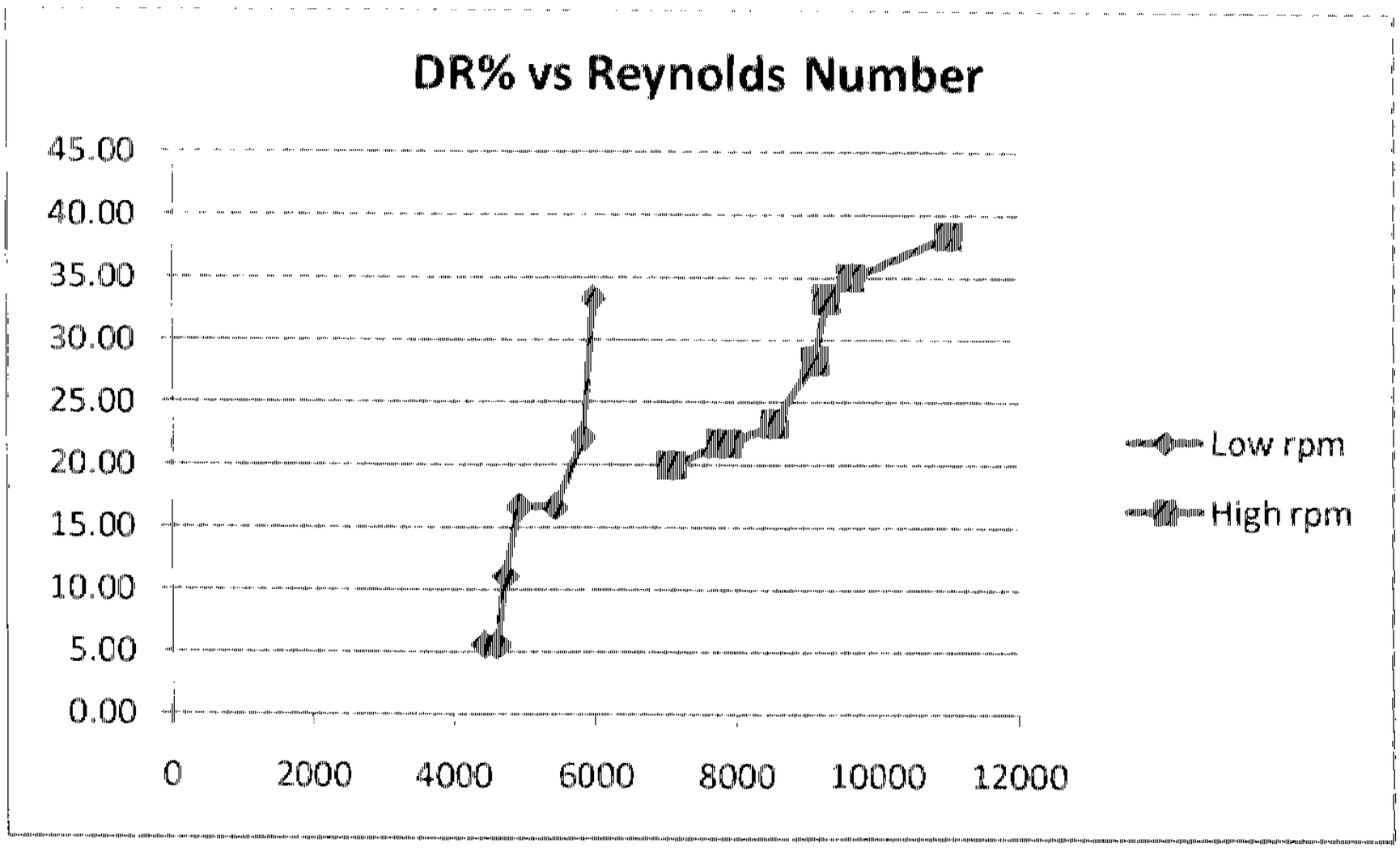


Figure 13: Drag reduction vs Reynolds number (different rpm)

Figure 11 show the effect of additive concentration on the %DR for *daun bekor* mucilage dissolved in water flowing through 0.0254 m ID pipe. Generally it can be noticed that the %DR increases by increasing the additive concentration. This is because, increasing the additive concentration of DRA means increasing the number of mucilage molecules involved in the drag reduction process where the turbulence spectrum increases under the drag reducer effect.

The results of this experiment also showed that within certain polymer type and concentration, %DR increases by increasng the Reynold Number, NRe (Figure 12. From the graph, the maximum value of %DR was 39% for the highest concentration which is 8000 ppm and for an NRe between 10000 and 20000 at high rpm of pump. The minimum value for the %DR was 5% and was observed for a concentration 100 ppm at low rpm of pump.

The degree of the turbulence increases proportionally with the increases of NRe. This is because, as the degree of the turbulence increases, the number of collisions between eddies is also increased, which causes smaller eddies to obtain.

The smaller the eddies, the lower energy will be absorbed by them. So it is much easier to suppress smaller eddies compared to larger one in the flow pipe system.

Since the graph does not show decreasing in %DR when DRA concentration and NRe keep increasing, the author can not determine the optimum value of %DR. Based on the results, it does not mean that this must be the optimum condition for the maximum %DR and it must be an indication about how important in controlling more than one variable in the same time for better drag reduction performance.

All the data were tabulated in the Table 5. (Refer to Appendix)

5. CONCLUSION & RECOMMENDATION

Daun bekor mucilage is introduced for the first time as natural DRA in pipelines carrying aqueous media in turbulent flow. In the present research, okra mucilage and aloe vera mucilage had been investigated to be used as natural polymer DRA since they contain high amount of natural polymers. From literature study and research, the author had identified that *daun bekor* mucilage also has the potential to be a new formulated DRA. Due to pressure drop happened after addition of *daun bekor* mucilage at the injection point of the flow system, it was proven that *daun bekor* mucilage can be possible DRA in pipeline. Generally, the %DR increases with increasing the addition of DRA concentration up to 39% drag reduction.

For future work, the author recommends to use special pressure gauge to measure pressure drop readings as in this present experiment, accuracy is the main problems. The equipment set up for this experiment also need some improvise to get more accurate data readings and to have an efficient progress in conducting the experiment.

REFERENCES

1. K. Robert Lange (1999). Surfactants A Practical Handbook. *Characterization of Surfactants*, 1-12.
2. Raoul Zana (1986). Surfactant Solutions New Methods of Investigation. Rheology of Surfactant Solutions, 209-237.
3. C. Kang and W.P. Jepson. Multiphase Flow Conditioning Using Drag Reducing Agents. *SPE, /Institute for Corrosion and Multiphase Technology, Ohio University.*
4. Katie Severson (May 13, 2005). Rheology of Drag Reducing Surfactant Systems. *Department of Chemical Engineering at The Ohio State University.*
5. Indra Prasetyo. Drag Reducer Increases Pipeline Capacity to Accommodate the Successful of Field Development. *PT Exspan Nusantara.*
6. Huey J. Chen, Gene E. Kouba, & M.S. Fouchi. Field Application of A Drag Reducing Agent to Increase Gas Production. *Chevron Petroleum Technology Co.*
7. Vlassopoulos, D. and Schowalter, W.R., 1994. Steady viscometric properties and characterization of dilute drag-reducing polymer solutions, 1427.
8. Virk, P. S. 1975 Drag reduction fundamentals. AIChE J. 21, 625-656.
9. Lumley, J. L. 1969 Drag reduction by additives. Ann. Rev. Fluid Mech. 1, 367-384.
10. Metzner, A. B. & Park, M. G. 1964 Turbulent flow characteristics of viscoelastic fluids. J. Fluid Mech. 20, 291-303.
11. http://www.sigmaaldrich.com/materials-science/material-science-products.html?TablePage=20204042
12. AV Shenoy, Colloid & Polym. Sci., 262, 319 (1984) JW Hoyt, "Drag reduction", in Encyclopedia of Polymer Science and Engineering, vol. 5, 1986
13. Oldroyd, J.G. 1949. A suggested method of detecting wall-effects in turbulent flow through tubes. Pages II130{34 of: Proc. 1st Intern. Congr. Rheol.
14. Elperin, I.T., Smolskii, B.M., & Leventhal, L.I. 1967. Decreasing the hydrodynamic resistance of pipelines. Int. Chem. Eng., 7, 276{295

15. Lumley, J.L. 1973. Drag reduction in turbulent flow by polymer additives. Macromol. Rev., 7, 263{290.
16. Virk, P.S., Merrill, E.W., Mickley, H.S., Smith, K.A., & Mollo-Christensen, E.L. 1967. The Toms-phenomenon - turbulent pipe flow of dilute polymer solutions. J. Fluid Mech., 30, 305
17. V.-T. Truong, DSTO-GD-0290 Drag Reduction Technologies, Maritime Platforms Division, Aeronautical and Maritime Research Laboratory.

APPENDICES

$$\%DR = \frac{\Delta P1 - \Delta P2}{\Delta P1}$$

1. ΔP1 is the pressure drop before the addition of drag reducers and ΔP2 is the pressure drop after the addition of r\drag reducers.

2. In this study, the Reynolds number is defines as:

$$NRe = \frac{\rho VD}{\mu}$$

3. The fanning friction factor will be calculated from the formula below:

$$f = \frac{\Delta P.D/4L}{\rho V^2/2}$$

4. Concentration in ppm:

$$\frac{1mg}{1000ml} = 1ppm$$

5. Concentration in %:

$$\frac{x}{100} = \frac{100g}{1000ml}$$

$$x = 10\%$$

UNIVERSITI TEKNOLOGI PETRONAS

Final Year Project II

Experiment Data Sheet

Name	Nurul Aida Hamdan
Project Title	Using Daun Bekor Mucilage As Drag Reducing Agent In Oil Pipeline
Date of Experiment	28-Jul-11
Time of Experiment	9.00 p.m
Experiment No.	1
DRA used	Daun Bekor mucilage (natural polymer)

Pipe Diameter, D	0.0254	meter
Flow Area, A	0.00050671	meter2

RPM of Pump	Low								
Concentration **ppm**	**Volumetric Flow Rate, Q** **m^3/s**	**Velocity, V** **m/s**	**Density, ρ** **kg/m^3**	**Dynamic Viscosity, μ** **kg/m.s**	**Reynolds Number, Re**	**Initial Pressure, P_1** **psi**	**Final Pressure, P_2** **psi**	**Pressure Drop, ΔP** **psi**	**Drag Reduction** **%**
100	0.0005422	1.07004 0062	999.89	0.00613	4433.283506	18	17	1	5.56
300	0.0005 60074	1.10531 4677	999	0.00611	4590.330246	18	17	1	5.56
500	0.0005 63619	1.11231 0789	999	0.00611	4619.384837	18	17	1	5.56
700	0.0005 78387	1.14145 5665	999	0.00613	4724.956104	18	16	2	11.11
1000	0.0006 01421	1.18691 3619	998.7	0.00612	4919.675497	18	15	3	16.67
3000	0.0006	1.30917	999.1	0.00	5428.5	18	15	3	16.67

	6337	0926		612	97039				
5000	0.0007 13201	1.40751 3173	999	0.00 613	5826.2 77939	18	14	4	22.22
8000	0.0007 30965	1.44257 0701	999	0.00 612	5981.1 52698	18	12	6	33.33

RPM of Pump	High								
Concentration ppm	Volumetric Flow Rate, Q m^3/s	Velocity, V m/s	Density, ρ kg/m_3	Dynamic Viscosity, μ kg/m.s	Reynolds Number, Re	Initial Pressure, P_1 psi	Final Pressure, P_2 psi	Pressure Drop, ΔP psi	Drag Reduction %
100	0.0008 6603	1.70912 3562	999.7 6	0.00 613	7080.1 50025	60	48	12	20.00
300	0.0009 47359	1.86962 7598	999.4	0.00 611	7767.6 0194	60	47	13	21.67
500	0.0009 61109	1.89676 3435	999	0.00 611	7877.1 87144	60	47	13	21.67
700	0.0010 44278	2.06089 8739	999	0.00 613	8530.9 10463	60	46	14	23.33
1000	0.0011 13627	2.19776 006	999	0.00 612	9112.3 01049	60	43	17	28.33
3000	0.0011 33172	2.23633 2419	999.1	0.00 612	9273.1 57007	60	40	20	33.33
5000	0.0011 78148	2.32509 3249	999	0.00 613	9624.5 20578	60	39	21	35.00
8000	0.0013 45753	2.65586 4301	999	0.00 612	11011. 68207	60	37	23	38.33